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POST LAUNCH REPORT

FOR.

MERCURY-ATLAS NO.1

(MA-1)\*

maneed by J. Shirley Date 11-27-73

Project MERCURY

Space Task Group

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, Wash, to. D.C.

August 2, 1960

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POSTLAUNCH REPORT FOR MERCURY-ATLAS No. 1 (MA-1)

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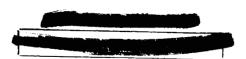
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

August 2, 1960

### FOREWORD

This Postlaunch Report is intended to provide initial correlation and a qualitative summary of the results of the Mercury-Atlas No. 1 (MA-1) flight test. Information is presented on Mercury capsule performance, Atlas booster performance and on the launch and recovery operations. The capsule performance information presented herein is derived from a "quick-look" analysis of limited data available at the launch site shortly after launch and as such must be considered preliminary data.

The MA-1 flight test is the first of a series of tests to be made with the Mercury capsule onboard the Atlas booster. The primary purpose of the MA-1 flight was to test the structural integrity of the Mercury capsule and its heat protection elements during reentry from a critical abort condition.



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### 1.0 SUMMARY

Mercury-Atlas No. 1 (MA-1) was launched at 8:13 a.m. E.S.T. on July 29, 1960 from Complex 14 of the Air Force Missile Test Center (AFMTC), Cape Canaveral, Florida. Atlas booster No. 50D was employed in the flight test.

The launch and flight of the MA-l capsule-booster combination were normal until about 58 seconds after lift-off at which time an abrupt disturbance of unknown origin occurred. At about 60 seconds after lift-off the booster apparently suffered major structural failures, the cause of which is not presently known. The capsule and capsule systems appear to have been operating properly at the time of booster failure. The capsule remained essentially intact after the booster failure and until impact. The capsule wreckage was located 4.6 miles due east of launch Complex 14. About 95 percent of the capsule had been recovered at the time of this writing. The capsule test objectives were not met.



### 2.0 FLIGHT TEST OBJECTIVES

The planned test objectives of the MA-1 mission, including the capsule objectives as well as the booster objectives, are outlined in the MA-1 Mission Directive (NASA Project Mercury Working Paper No. 132). The capsule first order test objectives are stated below:

- (1) Determine the integrity of the Mercury capsule structure and afterbody shingles for a reentry associated with a critical abort.
- (2) Determine Mercury-capsule afterbody heating rates during reentry.
- (3) Determine the flight dynamic characteristics of the Mercury capsule during reentry.
- (4) Establish the adequacy of the capsule recovery system and recovery procedures.

### 3.0 CAPSULE AND CAPSULE SYSTEMS

Figures 3.0-1 and 3.0-2 show photographs of the capsule and capsule-booster combination. The basic structural configuration and heat protection elements of the MA-1 capsule are the same as employed in the standard Mercury design with the exception of the escape tower. A stub tower, constructed from the lower portion of the standard escape tower, was employed to duplicate the structural joint at the tower clamp ring and to support a thermal fairing over the end of the antenna capister.

The primary systems and components employed onboard the MA-1 capsule are listed below:

- (1) Telemetry System (20-watt 16 continuous sub-carriers transmitting over standard Mercury discone antenna).
  - (2) Two Cook magnetic tape recorders.
  - (3) Two 16-mm Milliken movie cameras.
- (4) Standard Mercury heat exchanger (used only for internal capsule cooling during ground tests).
- (5) Standard Mercury retropack structure (used to house the (3) posigrade rocket motors).
  - (6) Explosive devices
    - (a) Stub tower clamp ring
    - (b) Main clamp ring
    - (c) Retropack release
    - (d) Drogue parachute mortar
    - (e) Antenna ejector
    - (f) Main and reserve parachute blast bags
    - (g) Main parachute disconnect
  - (7) Landing and Recovery Systems
    - (a) Drogue parachute
- (b) Main parachute (reserve parachute used for ballast only)



Figure 3.0-1 Photograph of MA-1 capsule with rain cover.



Figure 3.0-2 Photograph of MA-1 capsule booster combination at launch.

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## 3.0 CAPSULE AND CAPSULE SYSTEMS (Cont'd)

- (c) Two SOFAR bombs
- (d) Flashing light
- (e) Radar chaff
- (f) Dye marker (one pack in antenna canister and one pack to be ejected from capsule upon impact)
- (g) Two UHF, 15-watt, Ultra SARAH Recovery Beacons

The following measurements were telemetered from the capsule:

- (1) (51) Temperatures (shingles, heat shield, and structure)
  - (2) (1) Reference temperature
  - (3) Pitch rate
  - (4) Yaw rate
  - (5) Roll rate
  - (6) Longitudinal acceleration (high range)
  - (7) Longitudinal acceleration (low range)
  - (8) Normal acceleration
  - (9) Transverse acceleration
  - (10) Cabin pressure
  - (11) Voltage monitor
  - (12) Capsule time
  - (13) Shingle vibration (1 shingle)
  - (14) Heat shield cavity pressure
  - (15) Events

### 4.0 CAPSULE PHYSICAL DATA

The following are measured physical data which were determined during the prelaunch preparations of the capsule. Refer to figure 4.0-1 for definition of the axis system used.

Exit configuration (includes capsule, retropack and stub tower)

Gross weight	2561.52 lbs.
Center of gravity location	
Longitudinal - distance from capsule	
maximum diameter	X = -22.99 in.
Transverse	Y = 0.03 in.
Normal	Z = -0.29 in.

### Reentry configuration

Gross weight	2406.27 lbs.
Center of gravity location	
Longitudinal - distance from capsule	
maximum diameter	X = -21.13 in.
Transverse	Y = 0.03 in.
Normal	Z = -0.30 in.

### Moments of inertia

I <sub>x</sub> (roll)	$286 \text{ slug-ft}^2$
I <sub>y</sub> (pitch) I <sub>z</sub> (yaw)	508 slug-ft <sup>2</sup>
$I_{Z}^{J}$ (yaw)	$502 \text{ slug-ft}^2$

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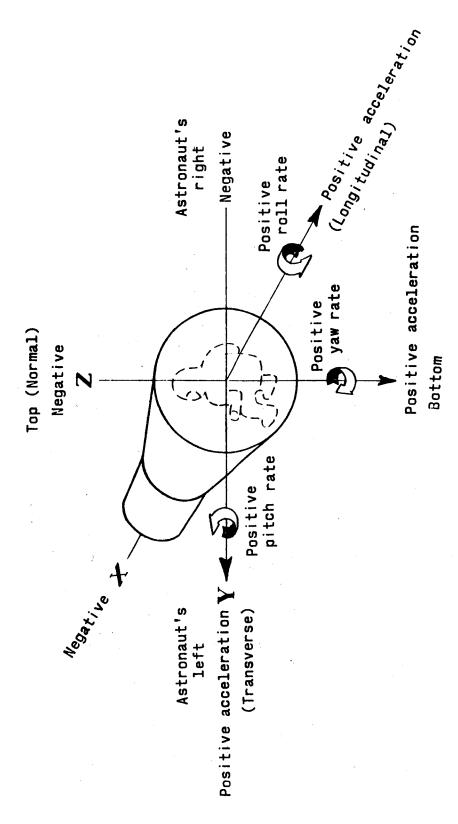


Figure 4-4.- NASA axis system to be used on all capsules for data reduction and presentation of capsule motions.

Figure 4.0-1. - NASA axis system used on the MA-1 capsule for data reduction and presentation of capsule motions.

### 5.0 FLIGHT PLAN

The normal flight plan for the MA-1 mission called for launching the capsule on a ballistic trajectory with a heading of 108° true down the Atlantic Missile Range (AMR). The Atlas booster guidance was programed so as to provide flight conditions at capsule separation to match the conditions for a particular poststage abort from a nominal Mercury exit trajectory. This particular abort imposes critical heating conditions on the heat protection shingles of the conical afterbody of the capsule. The desired trajectory matching conditions at sustainer engine cutoff are listed below:

Inertial velocity, ft/sec 18,953

Altitude, feet 547,033

Inertial flight-path angle, degrees 3.61

The planned MA-1 mission also was to simulate a condition where a complete control system failure is encountered since the capsule did not employ a stabilization and control system. The capsule motions during reentry would be dependent on the inherent aerodynamics of the configuration.

Separation of the capsule from the booster was to be effected by means of the three posigrade rockets carried in the standard Mercury retropack. No retrorockets were employed in the test. The Mercury capsule escape system was not installed for this flight.

The landing or descent phase was planned to include the use of both drogue and main parachutes. The drogue parachute was to be deployed at an altitude of 42,000 feet and the main parachute at an altitude of 10,000 feet. The reserve parachute was not intended to be deployed in flight, but was included in the capsule as ballast.

The capsule used in the MA-1 mission did not have the escape system which will be standard on other Mercury flights. In the event of an aborted flight before T+170 seconds, the capsule would not receive a separation signal. After this time, the capsule would be expected to separate from the booster in the normal fashion when the booster received the sustainer cutoff signal (MFCO or SECO).

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### 6.0 FLIGHT HISTORY

Mercury-Atlas No. 1 (MA-1) was launched at 8:13 a.m. E.S.T. on July 29, 1960 from Complex 14 of the Air Force Missile Test Center, Cape Canaveral, Florida. Atlas No. 50D was employed in the flight test.

The flight of the Mercury-Atlas test vehicle appeared normal in all respects for about the first minute following lift-off. At 58.5 seconds a large disturbance occurred which resulted in a forward acting shock load of about 25 g on the capsule. This disturbance apparently did not result in damage to the capsule or capsule systems, nor did it seem to result in loss of thrust of the booster. Approximately 1 second after the initial disturbance, the booster telemetry was lost and multiple radar targets appeared shortly thereafter. The capsule apparently did not sustain major damage from these events as evidenced by the data obtained from the continuous operation of all capsule telemetry channels to capsule impact, or for about 143 seconds after booster failure. The impact point as established by the radars was approximately 4 miles offshore. No capsule sequence events signals were recorded by the telemetry. This condition would be expected at this time of flight because the booster signals initiating capsule sequences were not to be enabled in the booster until 170 seconds. the landing and recovery system could not have been activated and did not function.

The capsule wreckage was found and recovered the day following the test in sixty feet of water near the predicted impact point.



### 7.0 RESULTS

### 7.1 Launch Operations

### 7.1.1 Prelaunch Activities

The capsule was delivered to the pad and mated to the booster on X-2 days. The capsule plastic rain cover was fitted and adjusted and checked out for proper umbilical ejection. During X-1 day the primary activity on the capsule involved making resistance checks of all pyrotechnic bridge circuits. These tests indicated that all pyrotechnics were satisfactory. Also during X-1 day, the normal booster activities were accomplished, and the booster was reported to be ready to start precount operations as planned. In the capsule precount, final checks were made on the capsule pyrotechnics, the batteries were connected, the hatch was installed and pressure checks were made. The booster precount activities proceeded normally with no apparent difficulties. As planned, the capsule and booster started the 215 minute detailed count at 3:55 a.m. EST.

Three holds and one recycle required an additional 43 minutes which increased the total countdown time required to 258 minutes.

Approximately 8 hours before launch time, the launch site weather conditions were intermittent rain and complete cloud cover. Local wind velocity was well within the limitations specified for this test. Weather forecasts predicted that visibility conditions would gradually improve. Weather conditions in the intended landing area were near ideal for capsule landing and recovery. Forecasts indicated that no appreciable change was likely to occur throughout this test.

During the count, all capsule and booster systems checkouts were accomplished smoothly with no apparent difficulties or changes to planned procedures. At T-35 minutes, the count was held for the following reasons: (1) Delays in the pyrotechnic hookup and (2) Delays in the preparation of camera equipment on the launch complex. These delays can be attributed mostly to the weather conditions. The aforementioned pyrotechnic and camera activities required about 15 minutes of the hold; the hold was then extended to evaluate the effect of the poor visibility on the launch pad camera coverage. It was decided that the existing photographic coverage was not so impaired as to justify further delay of the test. The total hold at this time amounted to 30 minutes. At T-7 minutes, the count was held to complete liquid oxygen sub-cooled topping. This delay was caused by difficulty in maintaining flight liquid oxygen level through the 2-inch topping lines This is a common occurrance. The required level was reached during the hold, and the count was resumed. At T-19 seconds a short hold of about 1 minute was required to determine the cause of no water ready light on the test conductor's console. It was



### 7.1.1 Prelaunch Activities (continued)

learned that the ready switch was inadvertently not thrown, and upon actuation of the switch, the light came on. The count was then recycled to minus 25 seconds and continued as planned with no other difficulties encountered. In general, the overall launch operation was smoothly integrated and conducted, and there was no indication at any time of any system malfunction in the capsule or the booster.

### 7.1.2 Weather Conditions at Launch

At the time of lift-off the weather was reported as follows:

### Planned landing area:

Clouds - .1 coverage with low cloud base at 2000 feet

Waves - 3 feet

Surface winds - 13 knots from 095 degrees

Visibility - 8-15 miles

### Launch site:

Clouds - .3 coverage at 1500 feet

.2 coverage at 3200 feet

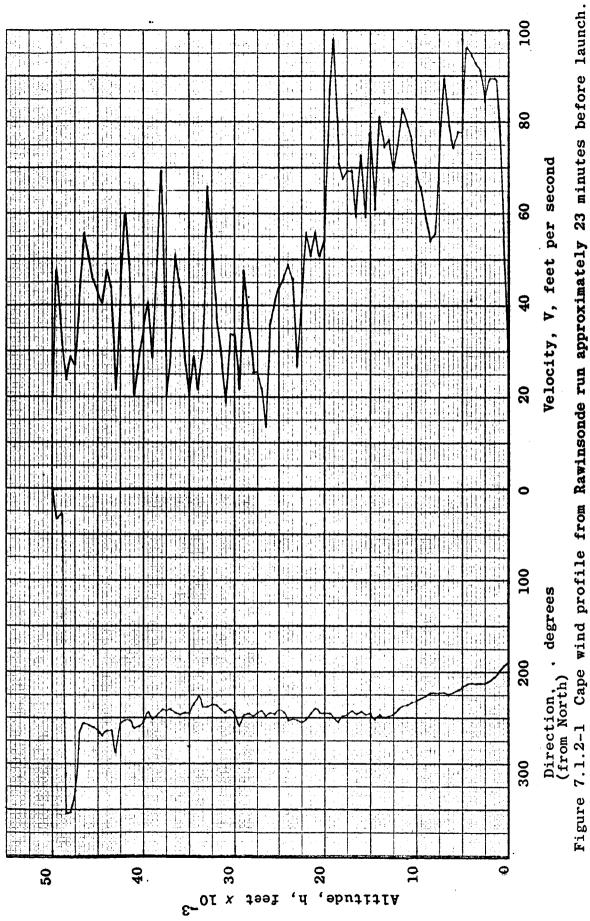
1.0 coverage at 9000 feet

Winds - See figure 7.5-3

Sea level pressure - 1008.8 millibars

Visibility - 3 miles in rain showers

An observation from the helicopter, airborne over the edge of the Banana River indicated rapidly lowering ceiling and visibility due to a low hanging rain cloud moving across the Skid Strip from the south.



### 7.2 Trajectory and Booster Performance

NOTE: RANGE ZERO TIME FOR THIS TEST WAS ESTABLISHED AS 13:13:03 ZULU. (2-INCH LIFT-OFF TIME WAS 13:13:03.92 ZULU) EXCEPT WHERE NOTED ALL TIMES GIVEN IN THIS REPORT ARE BASED ON RANGE ZERO TIME.

### 7.2.1 Trajectory

From lift-off to 36 seconds the G. E. Burroughs Guidance System yielded trajectory rate data which were intermittent and not suitable for reduction. The guidance system performed normally from 36 to 58.65 seconds (range time) at which time all lock was lost and never regained.

Real time impact prediction on the RSO plotboard was supplied by the Cape FPS-16 until 57 seconds. At this time an attempt was made to use AZUSA data. When AZUSA proved unusable, the Cape FPS-16 data were used from 73 seconds until loss of signal. The XN-1 radar was not used in the Impact Predictor computer because of mechanical difficulties in the data digitizer.

The trajectory data presented in this section is based on the data obtained from following tracking facilities:

<u>Facility</u>	Range time, seconds		
G. E. Burroughs	36-58.65		
AZUSA	34-58.65		
Cape FPS-16	10-20		
_	31-58		
	80-171		

After 58.65 seconds, the trajectory is based on the Cape FPS-16 data and an integrated trajectory using the G. E. Burroughs conditions at this time.

The following values were obtained from the Burroughs computer near the time when the powered flight was terminated.

Time, secs (Range time)	57.19	57.69	58.19
Latitude, deg north	28.4898	28.4896	28.4894
Longitude, deg west	80.5178	80.5166	80.5155
Altitude, ft	32589	33242	33878

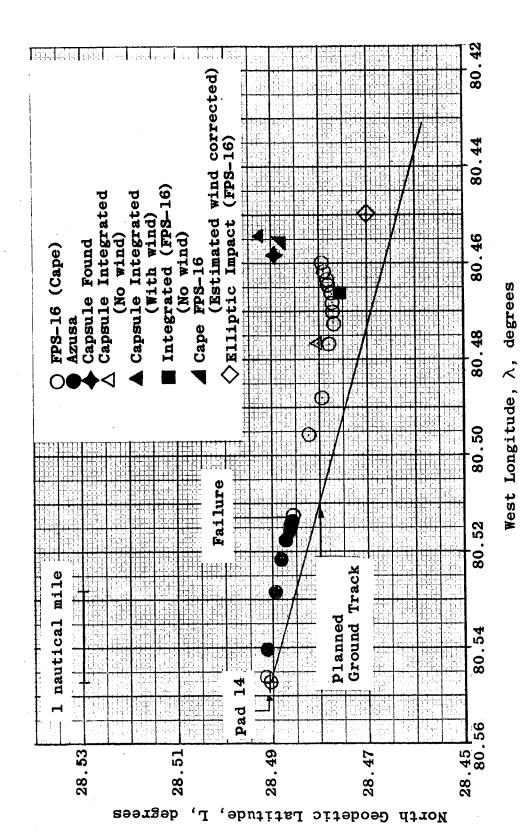
### 7.2.1 Trajectory (Cont'd)

Inertial velocity, ft/sec	2436	_	2483
Inertial flight path angle	31.93	-	32.02
(from horizontal), deg			
Inertial heading angle	94.96	-	95.16
(from north), deg			
Earth fixed velocity, ft/sec	1484	1506	1528
Earth fixed flight path	60.25	59.83	59.49
Angle, deg			
Earth fixed heading angle,	104.04	104.25	104.12
deg			
Mach number	1.51	_	1.56
Dynamic pressure, 1b/ft <sup>2</sup>	889	-	899

The Mach number and dynamic pressure given above are based on a standard ARDC 1959 atmosphere. Calculations using the density measured prior to the launch indicate that the dynamic pressures given above and in the figures of this section are about 8 percent low. The dynamic pressures encountered were approximately the maximum expected.

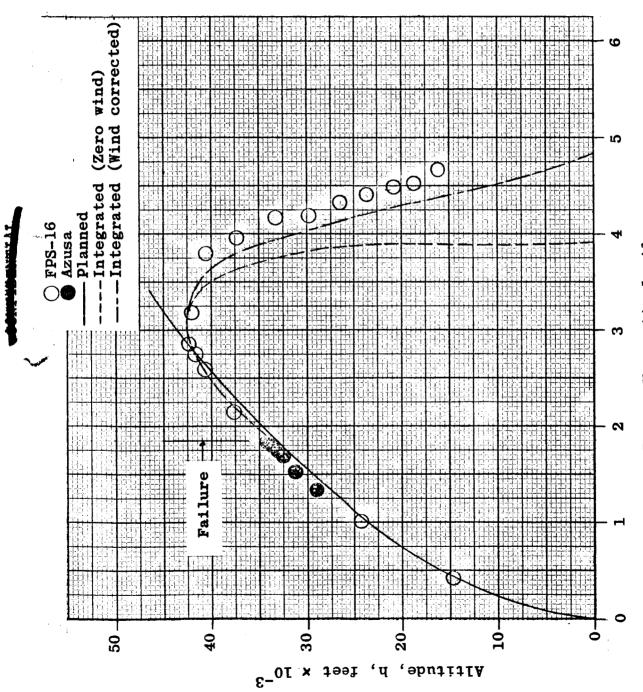
The ground track is shown in figure 7.2.1-1. Because of high winds (see figure 7.1.2-1), the track deviates considerably from the nominal.

A plot of altitude versus range is shown in figure 7.2.1-2. Time histories of trajectory quantities are shown in figures 7.2.1-3 to 7.2.1-5. Figure 7.2.1-1 shows the point where the capsule wreckage was located and recovered after the flight. Also shown are the impact point obtained from the Cape FPS-16 radar tracking, the impact point calculated from the conditions at the termination of powered flight based on G. E. data, and the calculated vacuum and integrated impact prediction computer The calculated and FPS-16 points were corrected impact point. The effects of the high winds at the lower for wind effects. altitudes can be noticed in the initial phase of the ascent and in the descent at altitudes below 30,000 feet. impact points supplied to the recovery forces immediately after flight were the FPS-16 elliptic and integrated values obtained from the impact prediction computer. More refined values were supplied on the day following the flight.



Flight Track, Impact Predictions, and Capsule Wreckage MA-1 Mission Recovery Point. Figure 7.2.1-1

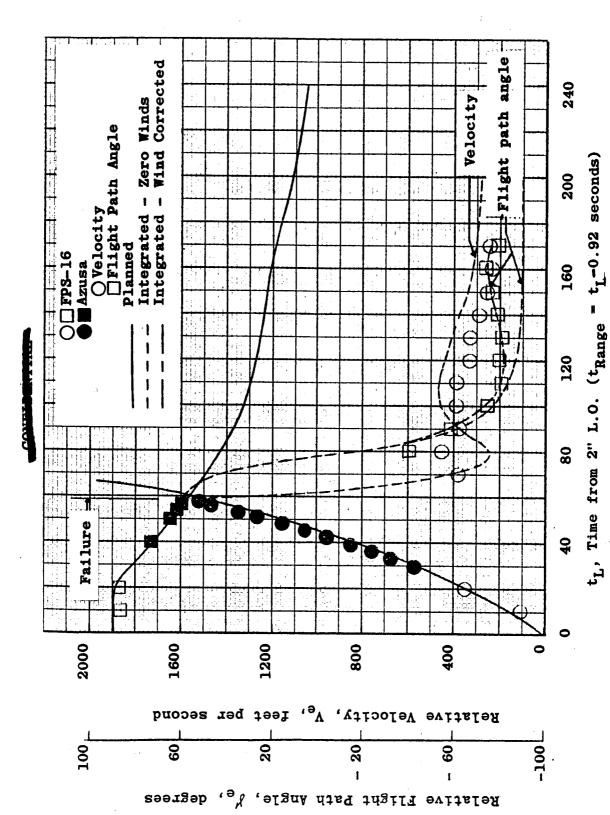
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Altitude - range profile for MA-1 mission. Range, X, nautical miles 18 Figure 7.2.1-2

Dynamic Pressure,  $\vec{Q}$ , pounds per square foot

dynamic pressure and Trajectory parameters: dynamic pressure Mach number versus time for MA-1 mission. Figure 7.2.1-3



Trajectory parameters: Flight path angle and velocity versus time for MA-1 mission. Figure 7.2.1-4

 $\epsilon^{-01}$  x leet x  $10^{-3}$ 

ಣ

Range, X, nautical miles

2

Zero Winds Wind Corrected

S

Range

Range and altitude versus time Trajectory parameters: for the MA-1 mission. Figure 7.2.1-5 CONTRACTOR

240

### 7.2.2 Booster Performance

Engine ignition appeared to be smooth and normal. Release and lift-off were normal after the planned hold-down time. Information presently available indicates that the booster performance was normal in all respects until 58.5 seconds after lift-off. At this time some booster telemetry was lost as a result of an unexplained abrupt event. This event caused large disturbances in the capsule and booster longitudinal acceleration data. The cause of this disturbance is presently unknown. There are strong indications, however, that after the disturbance, the engines continued to operate for a short period of time. It appears that sometime between 59.0 and 60.0 seconds, the booster experienced major structural damage.



### 7.3 Capsule Measurements

### 7.3.1 Motions and Loads

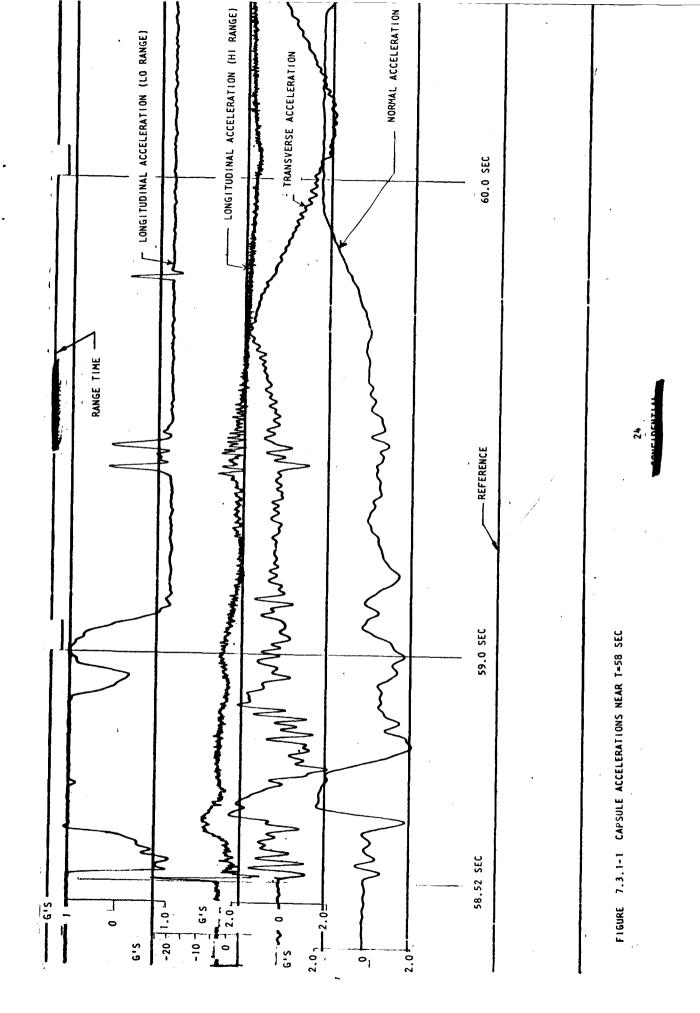
The MA-1 capsule motions and loads presented herein were obtained from the capsule flight telemeter records, portions of which are presented herein. See figure 4.0-1 for a description of the axis system.

The first indication of any deviation from normal launch angular rates and accelerations occurred at 58,52 sec from 2-inch motion as seen in figures 7.3.1-1 and 7.3.1-2. At this time a negative longitudinal acceleration impulse (in thrust direction) of greater than 25 g's was detected on the high range longitudinal accelerometer. This 25 g negative acceleration was attained at 58.52+0.006 seconds. At 58.52+0.012 seconds a 10 g positive acceleration was This cycle is completed in about 20 milliseconds. The level of longitudinal g's then went to zero for approximately 0.10 seconds then increased to 8 g's thrust for another 0.10 seconds before returning to the booster thrust level. At about 59 seconds the acceleration began to decrease in an irregular manner ultimately reaching a maximum of about 7.5 g retardation (drag). The capsule normal and transverse accelerometers also indicated some side loads of short duration at approximately 58.7 seconds; starting at 59.5 seconds both of these accelerometers evidenced an oscillation of the type that would indicate that the capsule and its possible attached booster parts was a free body. From the angular rate traces in figure 7.3.1-2 an abrupt change of all rates is seen at about 59.5 seconds.

Integration of the rates from 58.5 to 59.0 seconds indicate an angle change of close to 10 degrees. Correlation with booster telemetry data was not made because the booster data are questionable from 58.5 seconds to loss of booster telemetry.

Shown in figures 7.3.1-3 and 7.3.1-4 are the capsule acceleration and rate measurements near T+101 seconds. From radar tracking, the capsule at this time was at an altitude of approximately 40,000 feet and was descending. The rates and accelerations shown in this figure are typical for a tumbling maneuver.

The capsule accelerations and rates just before impact are shown in figures 7.3.1-5 and 7.3.1-6. The characteristics of the curves are again typical of a rapidly rolling and tumbling body.



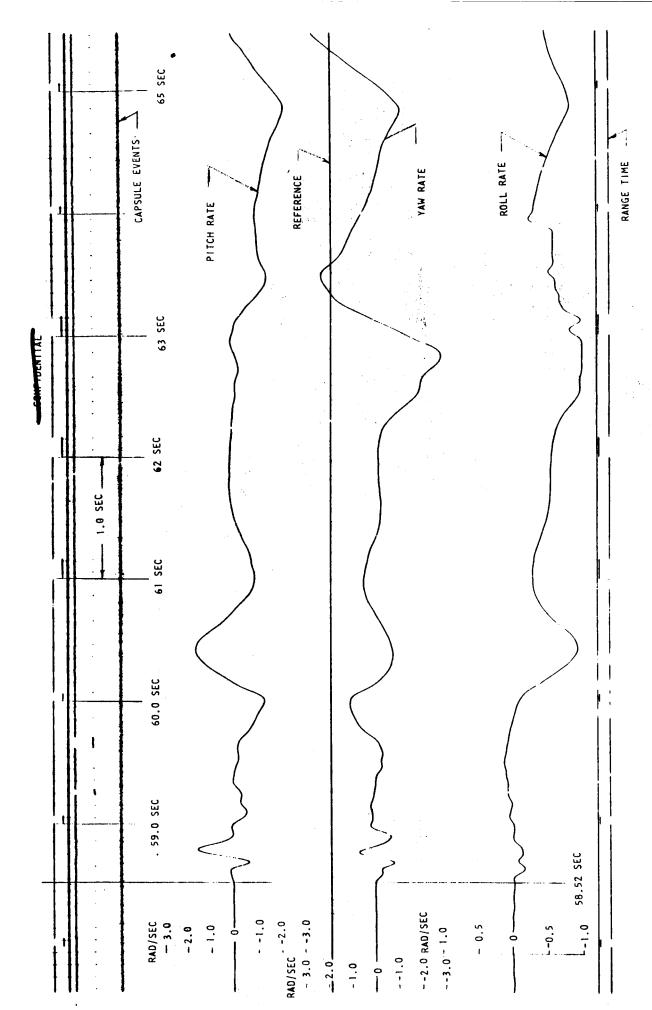


FIGURE 7.3.1-2 CAFSULE ANGULAR RATES NEAR T=58 SEC

52

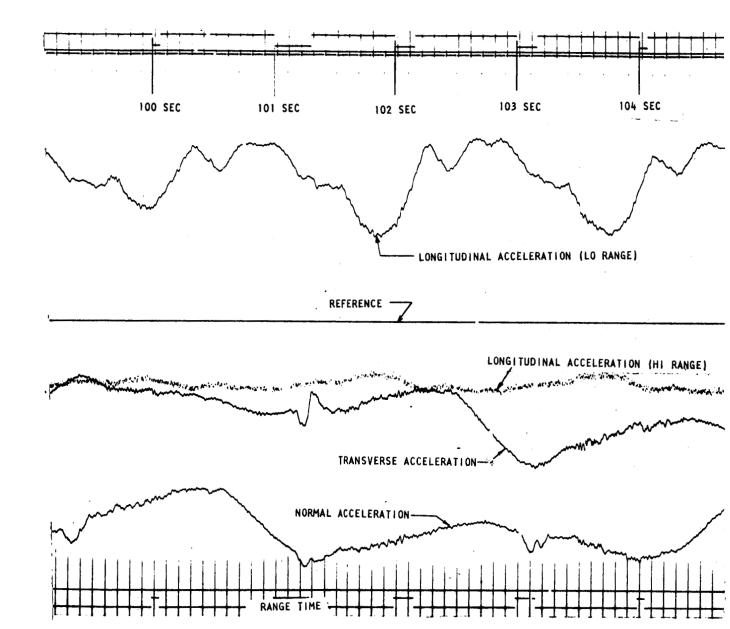


FIGURE 7.3.1-3 CAPSULE ACCELERATIONS NEAR T=100 SEC

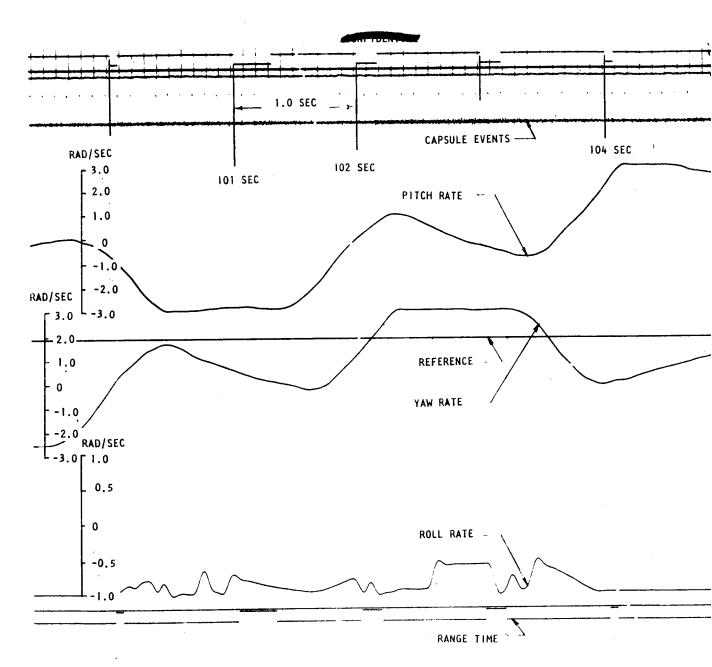


FIGURE 7.3.1-4 CAPSULE ANGULAR RATES NEAR T-100 SEC

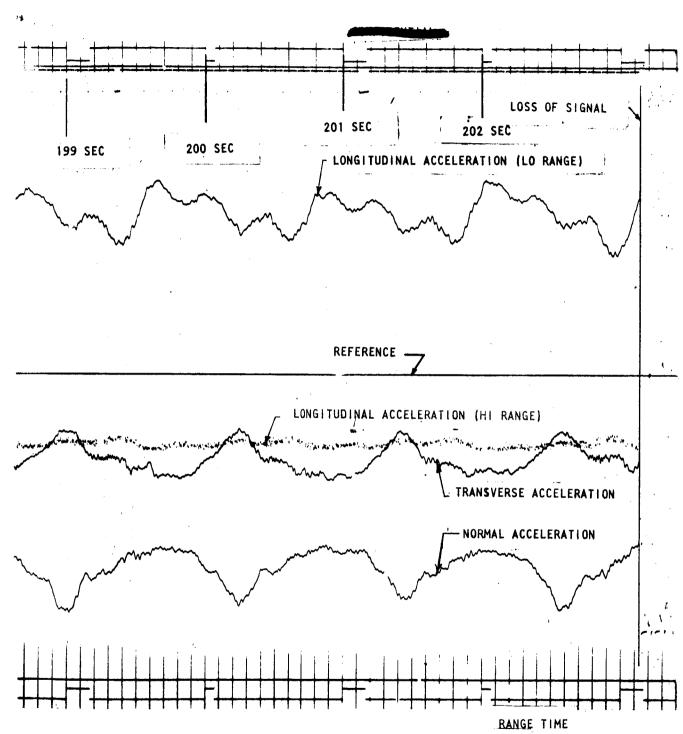


FIGURE 7.3.1-5 CAPSULE ACCELERATIONS PRIOR TO LOSS OF SIGNAL

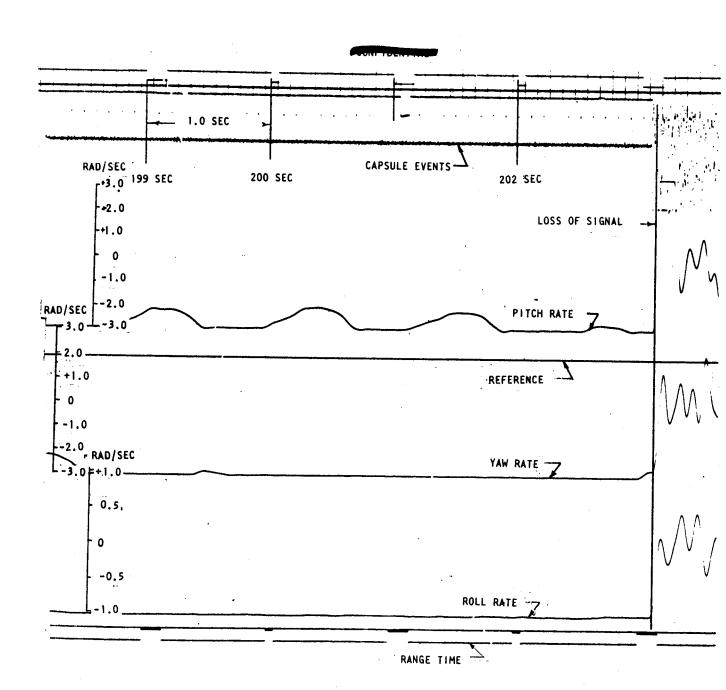


FIGURE 7.3.1-6 CAPSULE ANGULAR RATES PRIOR TO LUSS OF SIGNAL

29



### 7.3.2 Vibration Measurements

Accelerometer - The capsule high frequency vibrations (in the direction of the x-axis; see figure 4.0-1) as measured by the accelerometer during flight varied from approximately 1.0 g peak to peak, at 20 seconds of flight time, to approximately 3.0 g peak to peak during the 10 seconds prior to the apparent booster failure. The predominant frequency was 200 cps. The above data were measured by the capsule longitudinal accelerometer; the special accelerometers used for the FRF vibration measurements (see appendix) were not connected during flight.

NOTE: Frequencies above 300 cps would have been greatly attenuated by the flight accelerometer.

Strain gage - Shingle strain measurements indicated normal engine noise at lift-off and the expected aerodynamic noise up to a Mach number of 1. The predominant frequency of the observed shingle strain was at the shingle first resonant frequency of 350 to 400 cycles per second. The resonant frequency of the shingle was established by earlier ground tests. Above a Mach number of 1 the strain gage indicated large pressure and strain fluctuations at a frequency of 200 cps. These fluctuations did not appear to damage the shingle in that the strain gage continued to operate to water impact.

The capsule onboard tape recorders have been recovered intact and will provide additional data. Three additional shingles had strain gages direct-recorded on the tape recorders (not telemetered); in addition, a microphone, installed underneath a strain-gaged shingle was direct-recorded on a tape recorder. A preliminary examination of these data was made by direct playback of the recorder tapes and it was found that these data reflect essentially the same characteristics as observed from the telemetered strain gage data.

### 7.3.3 Other Measurements

Pressures - Figure 7.3.3-1 is a plot of the capsule cabin and capsule heat-shield-cavity pressure vs time.

The cabin pressure regulating valve located on the small pressure bulkhead appeared to function properly. The pressure decreased with altitude until the regulating pressure of approximately 5.4 psia was reached. At this point the cabin pressure held constant for about 50 seconds indicating that cabin leaks, if any, were negligible. The valve opened again during descent and equalized the pressure satisfactorily.

It should be noted that the valve continued to operate satisfactorily after the booster failure and that the cabin pressure remained constant during the time the valve was closed. It thus appears that the capsule pressure vessel remained structurally sound and sealed during and after the booster malfunction. There was no pressurization system on board the capsule.

Another point of interest is that the heat-shield-cavity pressure was not unduly high (figure 7.3.3-1) indicating that (at least for the low Mach numbers of this flight) the shock wave from the main clamp ring had little or no effect on the pressures in the cavity.

Heating - Because of the low speeds involved, no significant exit heating data were obtained from this flight.

The 51 thermocouples distributed throughout the capsule structure and shingles functioned properly from lift-off to capsule impact.

The thermocouples were attached to the capsule structure and shingles in such a manner that breakup of the structure or loss of a thermocoupled shingle in flight would have opened the circuit(s) of the affected thermocouple(s). Such an open circuit would have been immediately apparent.

From the pressure and temperature measurements discussed in this section, there is strong evidence that the capsule remained intact and structurally sound, during and after the booster malfunction, down to capsule impact.



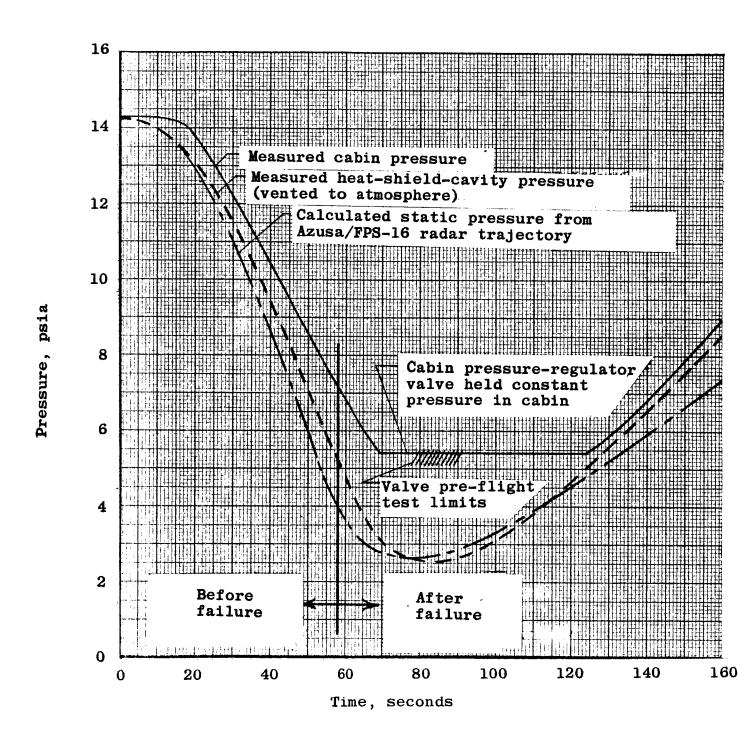


Figure 7.3.3-1 - MA-1 capsule pressure measurements

## 7.4 Capsule Systems Performance

### 7.4.1 Instrumentation and Telemetry

For the MA-1 launch, 203 seconds of data were obtained via the telemetry link. Evaluation of the onboard recorded portions of the instrumentation system is not included in this report. The onboard tape recorders have been recovered. The tapes are in good condition and are being processed at this writing.

Examination of the telemetry records showed all channels performed satisfactorily. Channel noise is modest (less than 2% of band width for all channels) and should not hinder evaluation and reduction. Zero shifts recorded during prelaunch checks are less than 2.1% of band width with the exception of the 7.35 kc channel, which had zero shifted 3%. No zero shifts were noted during flight.

At loss of signal, all sensors were intact including all 51 thermocouples and the single strain gage instrumented via telemetry. Evaluation of the cavity pressure channel, whose pressure sensor was exposed to atmospheric pressure, indicated data were received to capsule impact.

The brevity of the flight precluded the possibility of determination of antenna pattern by study of signal strength.



#### 7.4.2 Electrical Power

In general, the performance of the capsule's electrical power system, before and during the abbreviated flight, was satisfactory. During the prelaunch condition, all console switches and monitor functions were accomplished with no discrepancies noted. The capsule's main, camera, and recovery batteries were within the specified voltage tolerances prior to launch. The main (instrumentation) battery voltage was telemetered and remained constant at 27.4 volts until impact.

Analysis of the two event data traces (.96 kc and 10.5 kc), showed that the flight terminated before any of the programmed events occurred.

## 7.4.3 Other Systems

The sequencing, landing and recovery systems were not exercised during the flight since the flight was terminated before the systems were programmed to be enabled.

## 7.5 Recovery

The distribution of the recovery forces in the designated recovery areas is shown in figures 7.5-1 and 7.5-2. The general plan of action following launch was to transmit (by voice radio) the predicted landing point information from the recovery control center to the downrange recovery commander. The recovery commander would then activate appropriate electronic and visual aircraft search plans to locate the capsule. Following location, capsule pickup would be by either helicopter or ship, whichever could be done more quickly. There were no prelaunch movements of the recovery forces from the planned locations.

At approximately T+140 seconds (8:15 a.m. E.S.T.), the launch site recovery commander in the airborne helicopter was advised that radar was tracking a descending object and to stand by for vectoring to the impact area. The T-boats (see figure 7.5-1) reported no visual sightings and that visibility had deteriorated to  $0-\frac{1}{2}$  mile in rain showers. The helicopter was vectored to an area approximately 7 miles downrange on a bearing of 105 degrees from Pad 14. Radar tracking information and IP 709 and G. E. Burroughs impact predictions indicated the possibility of parts being scattered from 4 to 7 miles downrange. approximately 9:30 a.m. the T-boat from the northern position joined the helicopter in the search area. No indication of capsule or booster impact was found in the area. copter search was maintained (by successive reliefs by the two other helicopters) until approximately 10:30 a.m. sea conditions continued to deteriorate and were reported to be very choppy with 8 foot swells. At 11:00 a.m. the search was temporarily suspended due to the extremely poor search conditions.

Search operations were recommenced at 7:00 a.m. on July 30. Additional analysis of radar fixes and impact predictions indicated probable landing areas at  $3\frac{1}{2}$  and 5 miles due east of Pad 14.

At approximately 12 o'clock the T-boat began recovering capsule parts. Salvage operations were continued until sundown, and approximately 90-95% of the capsule, including all pyrotechnic devices were recovered. The capsule wreckage was located 4.6 nautical miles due east of Pad 14 on the ocean bottom in 60 feet of water. Figure 7.5-3 shows the recovery area. Salvage operations were resumed at 7:00



## 7.5 Recovery (Cont'd)

a.m. on July 31. As of this writing no significant amount of booster hardware has been recovered.

The following evaluation and conclusions are made concerning the recovery operations:

- a. The communications were good.
- b. The search and locating procedures were severely hampered by the poor weather and sea conditions.

The following recommendations concerning recovery are made for future operations:

- a. The launch site weather requirements for future operations, where the capsule escape system will be utilized, should be such as to provide the possibility of theodolite tracking of a capsule descending in the launch site area.
- b. An aircraft equipped with a SARAH receiver should be provided in the launch site area for an additional indication of recovery system sequencing.



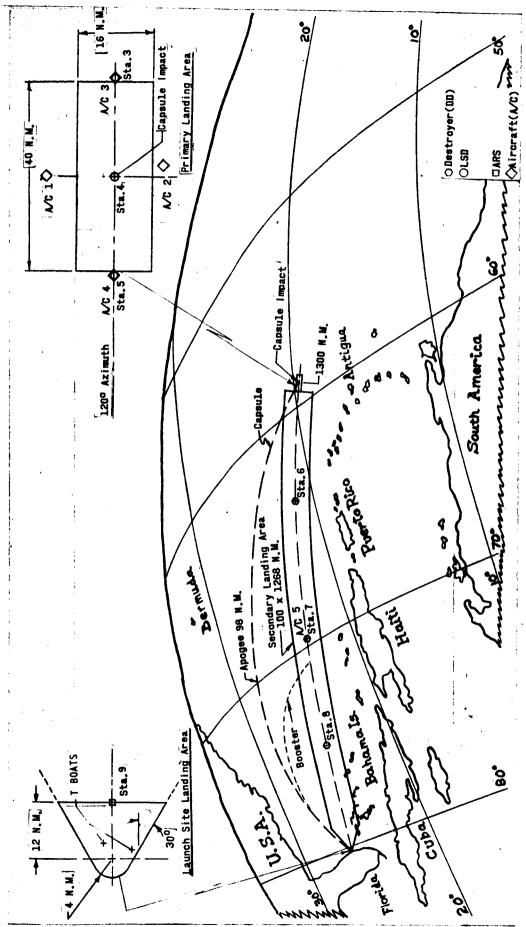


FIGURE 7.5-1 Location of Ship and Aircraft Stations in Designated Recovery Areas.

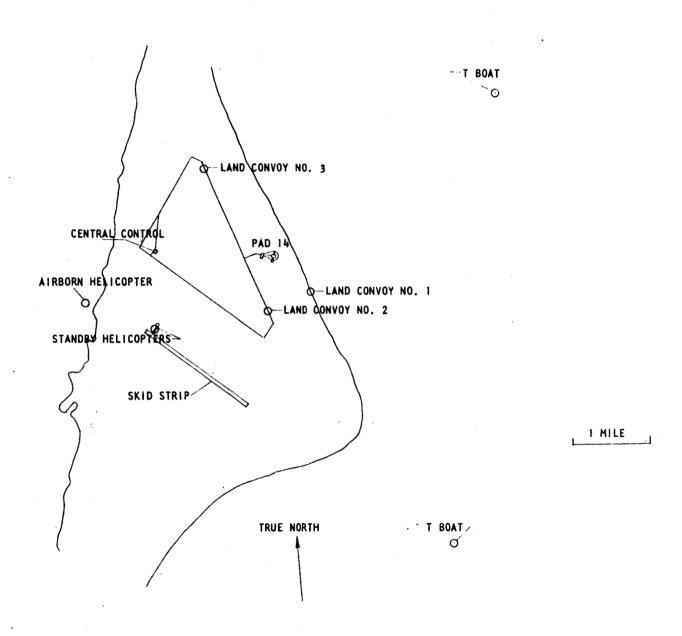
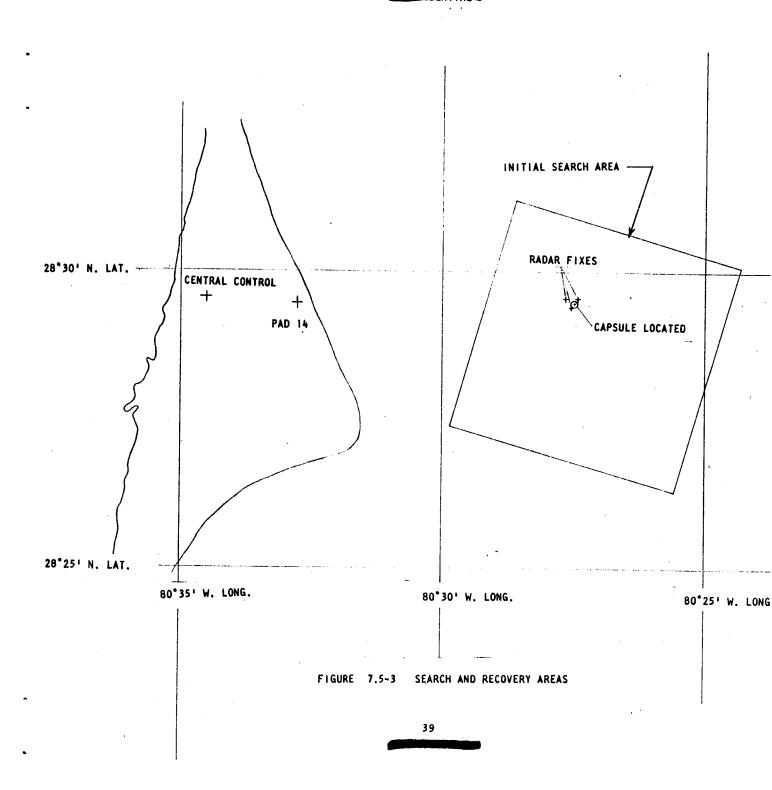


FIGURE 7.5-2 LAUNCH SITE RECOVERY FORCES DEPLOYED IN THE CAPE AREA





## 7.6 Capsule Postflight Inspection

As previously stated in the Section on Recovery, approximately 90 to 95 percent of the capsule wreckage was recovered. All of the recovered capsule parts were found in a circular area of approximately 50 foot radius indicating very strongly that the capsule was intact at the time of contact with the water. From a general inspection of the wreckage, it appeared that at impact the capsule must have been tilted such that first contact was made by the edge of the heat shield and the region of the conical section between stringers 16 to 23. (The entrance hatch is located in this area of the conical section.)

All pyrotechnic devices and explosives on board the capsule were recovered with the exception of one parachute eject bag gas generator and the two auxiliary umbilical explosive disconnects. All the recovered pyrotechnic devices were examined, and it was verified that none had fired, with the possible exception of the two parachute reefing cutters (see below). All three posigrade rocket motors were recovered. Two of these had been torn away from their mountings in the retro pack, one motor still remained attached. None of the three motors had been fired. Both SOFAR bombs were also recovered. One of these bombs had a ruptured case; however, the powder charge was still intact.

The capsule telemeter, programmer, on-board recorders and on-board cameras were recovered. The recorders were examined and determined to have functioned properly. The recorder tapes have been reproduced and found to contain data on all six tracks.

The main parachute was recovered, but the reserve parachute was still missing at this writing. The shroud lines of the main parachute were found to have been pulled from the deployment bag, and hence it is felt that the two reefing cutters may have been triggered by this action; however, this has not been definitely established at this time. The antenna canister with the drogue parachute and mortar were recovered practically intact. All aneroids, the SARAH beacons and flashing light were also salvaged.

The main and tower marman bands and their fairings were recovered in toto. The stub tower was found wedged tightly against the antenna fairing. One-half of the fiberglass covering on the blast shield of the stub tower was still attached to the blast shield; however, the other half was missing. There was no evidence of any erosive action on this covering.

# 7.6 Capsule Postflight Inspection (cont'd)

The ablation shield was extensively damaged in the area of impact and suffered loss of a large section and general delamination. Some shingles were individually recovered, and many were still attached to the general capsule wreckage; however, it is not possible to give an accounting of shingles at this writing.

One small section (about 10 inches long) of the adapter ring was located with the capsule wreckage. A portion of the adapter skin structure approximately 10 inches square was also located with the capsule.

The only portion of the booster found in the capsule impact area was the lox boil-off valve. This valve was located in the vicinity of the capsule heat shield--approximately 15 feet away.

## 7.7 Range Instrumentation Performance

Atlantic Missile Range (AMR) instrumentation support was very good for this test. All instrumentation committed to the test, except for a few optics items, were manned and operational. The solid cloud cover prevented the optical instrumentation from providing information as to the failure that occurred.

Following is preliminary information on the status of instrumentation and coverage obtained.

# Optics:

	No. of Items	No. of Items
Type	Committed	<u> </u>
Metric	13	12
Engineering Sequential	43	39
Documentary	37	41

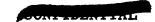
#### Radar:

Although radars at Patrick, Cape Canaveral and Grand Bahama Island (GBI) were committed to support the test, only those at Patrick and the Cape acquired and tracked. Preliminary tracking results indicate the following.

		Tracking Time
Station	Type	From To
Patrick	XN-1	+30 sec +205 sec
Cape	FPS-16	+16 sec +160 sec
Cape	Mod. II	+15 sec +170 sec
Cape	Mod. II	+15 sec +170 sec
Cape	Mod. IV	+8 sec +80 sec

### Telemetry:

Station	<u>Item</u>	<u>Link</u>	Receiving From	
Cape	TLM 18	I (Booster) II (Capsule)	0 sec 0 sec	+59 sec +203 sec
GBI	Tri Helix	I (Booster) II (Capsule)	+52 sec +52 sec	+62 sec +172 sec



## 7.7 Range Instrumentation Performance (cont'd)

## AZUSA;

Preliminary information indicates AZUSA coverage from +30 sec to +60 sec.

## Command Functions:

The Range Safety Officer transmitted the manual fuel cutoff signal as planned at 0817:25.5 Eastern Standard Time (261.58 seconds after 2-inch liftoff). This transmission had no bearing on the test since, as established later, failure and impact had already occurred at this time.

#### 7.8 Film Review

Ignition, liftoff, and powered flight appeared normal in the engineering sequential films. Due to the unfavorable weather conditions, the tracking film coverage (perimeter cameras) was very poor both as to duration and quality. silhouette of the test vehicle disappeared at T + 27 seconds (altitude about 7500 feet) and the booster flame was not visible after T + 36 seconds (altitude about 11,000 feet). The quality of the fixed camera coverage (launch site cameras) was acceptable for the intended purpose. The coverage was good with the exception that capsule umbilical release and stub tower raincoat pull-off were not recorded. (Umbilical release and tower raincoat pull-off were visually observed from the blockhouse and were satisfactory.) Fixed camera film did show that the tower raincoat was dangling along the side of the Midas tower at lift-off, indicating proper re-It was observed that the stub tower raincoat was intact up to the time it was pulled. The lower raincoat on the conical section of the capsule was torn (from the bottom up to approximately the window) on the leeward side, but appeared to provide ample protection. From the films, the Atlas engine firing sequence was observed to be sustainer, booster #1, booster #2, and verniers last.



The Mercury-Atlas No. 1 flight test was abruptly terminated approximately one minute after launch by an in-flight failure of an undetermined nature. Solid cloud cover at the time of launch precluded the use of optical records in the investigation of this failure. The following conclusions are made regarding this flight test:

- 1. None of the primary capsule test objectives were met.
- 2. The structural integrity of the capsule was maintained throughout the flight until impact with the water.
- 3. The capsule on-board instrumentation performed in a highly satisfactory manner throughout the flight to impact with the water.
- 4. The on-board instrumentation showed the presence of shingle vibration of a non-destructive nature near a Mach number of one.
- 5. The cabin pressure regulator performed satisfactorily throughout the flight.
- 6. All other on-board systems (landing and recovery) were not exercised because of the conditions under which the flight was terminated.
- 7. All Department of Defense support for the operation was very good.

#### 9.0 RECOMMENDATIONS

- 1. The next Mercury-Atlas mission (MA-2, capsule No. 6) should be revised so that the test objectives originally designated for the MA-1 mission can be achieved.
- 2. The determination of the cause of failure of the MA-1 flight test should be vigorously pursued in order that any changes deemed necessary to capsule or booster hardware may be incorporated prior to the next test. Fulfillment of this recommendation requires continued concerted effort on recovery of parts of the MA-1 booster.
- 3. For at least the next two Mercury flight operations, weather conditions should be such as to allow good detailed photographic coverage during the powered phase of flight to the range limits of the best AMR tracking cameras.

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#### 10.0 APPENDICES

#### 10.1 Capsule History

Capsule number 4 (MA-1) arrived at Cape Canaveral Missile Test Center at 3 p.m. on May 23, 1960. The capsule was complete except for flight instrumentation, parachutes and pyrotechnic devices.

Following a satisfactory leakage rate test, the capsule wiring was verified during which time all the instrumentation was being finally bench-tested as a system.

The first overall instrumentation tests in the capsule revealed unanticipated difficulties materially affecting the planned work schedule. Changes in philosophy for hangar checks became necessary. All malfunctioning flight instruments were replaced by a backup system, or a dummy weight, so that work could proceed both on the capsule weight and balance measurements and the flight instruments. This work required two additional weeks over and above the scheduled work period. This slippage was caused by procedural problems with the weight and balance fixtures as well as the aforementioned difficulties with the operation of the overall instrumentation system.

Following this period capsule systems tests were run in the hangar capsule checkout room. These tests formally verified the sequence system and the instrumentation system. Minor discrepancies were noted in the instrumentation system during the capsule system tests, but fixes were scheduled during the complex testing in order to accomplish the First Mate with the booster as early as possible. Calibration curves for the freon and portable air-conditioning units were also established.

The first mechanical mating of the capsule with the booster (No. 50D) occurred on July 5, 1960. Alignment was good and no rework was required. Instrumentation tests and preliminary umbilical pull tests were performed and were satisfactory. plex wiring and blockhouse consoles were found to be in good Mechanical problems with freon cooling and booster electrical interface plus thundershowers forced postponement of the test.

The First Mate and Instrumentation Test was successfully completed on July 6, 1960. The landing and recovery systems were subjected to capsule power and RF radiation and all of the 1/16 ampere fuses, simulating pyrotechnic igniters, survived the test.

The capsule was returned to Hangar S. Instrumentation and telemetry packages were removed and reworked. A new aerodynamic fairing for the upper clamp ring was fitted to the capsule. heavier gauge periscope door was fitted and installed. reassembly and brief instrumentation tests, the capsule was again mated to the booster in preparation for the Flight Acceptance Composite Test (FACT).

## CONTIDUMN FIRM

## 10.1 Capsule History (cont'd)

The FACT was attempted July 13 and proceeded to T-90 minutes. It was postponed as a result of malfunctions of booster systems. These systems were mandatory for this test both from the standpoint of booster as well as capsule test objectives.

A second FACT was conducted the following day, and the desired results were obtained until about T-3 minutes when the capsule telemetry RF power amplifier and associated power supply failed. This failure was determined to have resulted from a high voltage standing wave ratio (VSWR) caused by the close proximity of the metal legs of the stub tower. Antenna loading studies were conducted with various parts and mock-ups of the stub tower. A configuration in which four of the six stub tower legs incorporated 2-inch insulation inserts resulted in a configuration suitable for proceeding with the test program. After modification of the tower legs and necessary tests, the FACT was satisfactorily concluded on July 18.

The Flight Readiness Firing Test (FRF) was conducted on July 21. No problems with the capsule were encountered. All of the four-amp fuses simulating pyrotechnic igniters in the capsule landing and recovery systems were blown during the FRF or in a special test immediately after the FRF. A satisfactorily low cabin leakage rate was measured before and after the FRF.

Between FRF and launch, the capsule was returned to the hangar, the tape recorders and cameras were removed, reloaded, and replaced, the telemetry was checked, and the recovery section equipment was removed. The capsule was then reassembled with live pyrotechnics (except posigrade rockets) and installed in the optical alignment fixture. The weight and lateral c.g. position of the separation configuration were redetermined and the live posigrade rockets were realigned to this c.g. Two of the four insulators in the stub tower legs were lengthened to further reduce the VSWR. The capsule was moved to the complex for launch and fitted with a ployethylene rain cover. Umbilical pull-tests were made to develop and qualify this rain cover.

The launch operation was normal and uneventful, except for difficulties encountered in the extremely wet conditions on the gantry. Some difficulty was experienced in checking and hooking up pyrotechnics, because of the necessity of maintaining dry conditions at the connectors.

# COAL ADDRAG

#### 10.2 FRF Vibration Measurements

During the flight readiness static firing of the engines, capsule accelerations were measured parallel and normal to the capsule x-axis (see figure 4.0-1 for description of capsule axis system). The accelerometers were mounted on the capsule basic structure (trunnions). The response of the vibration-measuring system was essentially flat from 20 cps to 2,000 cps.

The direction of the normal accelerations was 20° counter-clockwise from the y-axis (viewed along the x-axis in the positive-acceleration direction - see figure 4.0-1). Accelerations in both directions showed overall r.m.s. valves at approximately 3.0 g. A power spectral density distribution of each using a 25 cps (approximately) filter band showed peaks at the following magnitudes at the indicated frequencies:

Longitudinal		Normal		
Frequency cps	g <sup>2</sup> /cps	Frequency	g <sup>2</sup> /cps	
190	.09	390	.040	
330	.034	730	.026	
750	.015			